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SUMMARY PROGRESS REPORT—1977
U.S. GRAIN MARKETING RESEARCH CENTER

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PREFACE

This is a summary report of activities and accomplishments of the U.S. Grain Marketing Research Center (USGMRC) in FY-1977, during which there was strength and growth in many areas. We have expanded, with limited personnel, by the addition of several key scientists who enhanced our program by contributing to staff interaction, and by better utilization of physical facilities. The growth was made possible by good use of our two strongest assets: (1) the availability, under one roof, of human and physical resources for interdisciplinary research, and (2) the recognition that long range basic and applied research, responsive to immediate needs, make a powerful and successful combination. We have found that the time-proven route from new concepts through applied investigations (laboratory, pilot plant, and field), to development of new products or methods, is still the best return on the taxpayers' investment in research. Some of our studies were conducted in cooperation with scientists in other USDA Agricultural Research Service facilities and in several universities. Most of our collaborative studies were with researchers at the Kansas Agricultural Experiment Station, an effective and mutually beneficial cooperative effort.

Most of our growth and expansion has been in areas involving cooperation with such action-regulatory agencies as the Federal Grain Inspection Agency (FGIS), Agricultural Marketing Service (AMS), Foreign Agricultural Service (FAS), and Office of General Sales Manager. Representatives of those agencies are users for our services because the work involves developing objective, simple, rapid, and inexpensive tests that can be run routinely under difficult conditions and by new personnel with limited specialized training. The tests must provide information that can be related directly to all segments of grain production, marketing, processing, and utilization.

With the establishment of our new Grain Quality Characterization Unit, much new work has been initiated and is in the pipeline. In addition, earlier work is being completed. Useful technology has resulted or is being developed to determine sprout damage and relation of that test to end-use properties, a method for degree of rice milling, a method to determine moisture in high-moisture grain, and others. In addition, in cooperation with FGIS and AMS, we conducted a survey to characterize insect and microflora activity in wheat and corn shipped from export elevators in the U.S.A., and followed changes in identity-preserved shipments of wheat from the country to the export elevator. The USDA-action agencies, agricultural attaches, and the grain trade have shown interest in another one of our comprehensive studies on the breadmaking performance of high-yielding European and U.S.A. hard wheat blends.

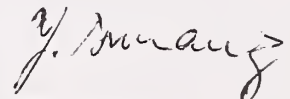
The past year has been a good one for the biologists among us. They have characterized the insecticidal parasporal crystal and isolated and purified the protoxin in *Bacillus thuringiensis*. Isolation and purification of the granulosis virus of the Indian meal moth was followed by characterization of its deoxyribonucleic acid (DNA)—one of the largest DNA molecules ever isolated in pure form. A gastrin-like peptide was discovered in the insects' cerebral neurosecretory system and hypoglycemia was introduced in insects with antidiabetogenic drugs. The biologists have learned how stored-product insects regulate the juvenile hormone titer in hemolymph and have determined the efficacy of several new insect growth regulators and insecticides on stored-product insects. Work on the genetic control of stored-product insects (by breeding insect-resistant cereal grains) was continued. Field trials to control insects in export hay by fumigation were conducted in cooperation with FGIS, AMS, and Animal and Plant Health Inspection Service.

Biochemical indices of fungal growth were studied. We have taken a new look (both conceptually and literally—under the microscope) at the structure of cereal grains to learn how that structure governs overall quality and consumer acceptance. We have found that the available biochemical information on the performance of flours in breadmaking can be amplified by light, scanning, and transmission electron microscopy.

Over the years, our Hard Winter Wheat Quality Unit has made nationally and internationally well recognized contributions to unravelling the mysteries of breadmaking potential, to developing new testing methods, and to the screening, yearly, of thousands of new wheat selections and cultivars. This team work (in cooperation with State and USDA geneticists, plant breeders, plant pathologists, entomologists, chemists, and food technologists) has produced much improved wheat cultivars. Varieties released during the last decade have an excellent combination of agrotechnical and functional (in breadmaking) properties. The improvement in protein quality has been so great that it is possible today to produce acceptable bread from wheats containing up to one percentage point less protein than 10 years ago. The high cost of fertilizers, the increase in yields, and the desirability of high protein wheats in breadmaking make it mandatory to increase protein content in high-yielding wheats by genetic means. We are proud to be part of a program (involving USDA, State, and private plant breeders) that has produced several new and agrotechnically acceptable cultivars with up to 3 percentage points more protein than in present cultivars. We have learned and we have told the scientific community about wheat flour lipids—what they are, what they do, how they interact with proteins, and what they can be made to do in the production of better bread. New work has been done on the production of nutritious and consumer-acceptable high protein and fiber bread.

Our engineers have studied methods of minimizing fuel requirements in grain drying, of reducing damage and dust formation in grain handling, and of optimizing the mixing of solids. They have looked into the identity, measurement, utilization, and control of the dust and broken kernels. We are adding human and physical resources to strengthen those important areas and are confident that useful information will be forthcoming in the near future.

The vitality and strength of a research center can be judged by the quality, dedication, and productivity of its scientists. The list of publications for the past year speaks for itself. The excellence of our scientists has been recognized by numerous invitations to present lectures, appointments to editorial boards, selections to organize national and international symposia, and appointments to act as scientific editors of prestigious series of advances. Many hundreds of visitors—individuals and groups—toured our facilities. Distinguished visitors, of varied scientific professions, from 42 countries throughout the world, and from practically all states in the U.S.A. came to see our research facilities, to acquaint themselves with our activities, to share their thinking with us, and to consult with our scientists about novel approaches and new developments. Their stays ranged from a short visit to several weeks of research work. Those visits, along with innumerable requests for information, interviews, lectures, and participation on committees, acknowledge our diversified activities as a Center of Grain Marketing Research.



Y. Pomeranz
Director, USGMRC

September 30, 1977
Manhattan, Kansas

CONTENTS

Grain structure and composition unit 1
Grain composition 1
Grain structure 1
Use of enzymes 1
Mycotoxins 1
Corn and sorghum quality 2
Biological research unit 2
Insect biochemistry and physiology 2
Pesticide biochemistry 2
Insect pathology 3
Pest bionomics 3
Genetic resistance in seeds 3
Engineering research unit 3
Minimizing fuel energy required for grain drying 4
Measurement and control of dust from grain handling 4
Reduction of damage to grain from handling 5
Grain quality and end-use properties unit 5
Determination and evaluation of functional properties of potentially new hard winter wheats 6
Evaluation of new high-protein hard winter wheats 6
Effects of solvent extraction on lipid composition, mixing time, and bread loaf volume 6
White wheat bran and brewer's spent grains in high-fiber bread 6
High-yielding European wheats: determination of end-use properties 7
Separation of glutenin from gliadin by ultracentrifugation 7
Short-time baking systems. A 70-minute sugar-free formula for conventional and high-protein breads 7
A simple 100-gram dough molder 8
Grain quality characterization research unit 8
Determination of moisture in wet grain 8
Degree of milling of rice 8
Measurement of protein in Hard Red Winter wheat by near infrared procedures 9
Economic Research Service—Commodity Economics Division 9
Grains and feeds program 9
List of publications 9
Invitational papers, technical presentations and other reports 15
Staff 19

GRAIN STRUCTURE AND COMPOSITION UNIT

Scientists in this unit conduct investigations to (1) identify composition of cereal grains in relation to storage, handling, utilization, and nutritional value; (2) determine relation of structure of cereal grains to storage, handling, and use; (3) determine use of enzymes in determination of composition, structure, storability, and damage during handling of cereal grains; (4) identify, control, and eliminate mycotoxins from cereal grains; and (5) assay the protein contents and biological value of cereal grains, in particular, maize and sorghum.

Grain Composition

The approach in these studies is to determine protein, lipid, mineral, and carbohydrate contents and interaction products among grain components as they relate to storage, handling, use, and nutritional value. The studies are designed to provide information, on composition of cereal grains, to other units in the USGMRC in investigations on the effects of composition on handling, storage, end-uses, nutritional value, and development of quality tests. Examples of studies in this area include determination and characterization of lipids (including the role of lipids in breadmaking), interaction between lipids and proteins, and determination and characterization of proteins. The information has been used in the development of nutritionally improved, consumer-acceptable, baked products.

Grain Structure

Cereal grains and products of their processing are studied by microscopic methods (light, scanning electron, and transmission electron microscopy). These studies are designed to correlate grain structure with market quality investigations conducted in other research units in the Center. Examples of studies in this area are comprehensive investigations on the structure of cereal grains, changes in the structure of dough and bread, structure of dough and bread from flours varying in breadmaking quality, and relation of grain structure to handling (corn breakage), storage (damage by molds and insects), end-uses, nutritional value, and development of quality tests.

Use of Enzymes

Enzymes are used to determine composition (proteins, carbohydrates, lipids, glycolipids, lipoproteins, and glycoproteins) and nutritional value of cereal grains (including availability of nutrients and their modification during handling, storage, and processing). Enzyme activity is assayed to determine grain quality such as sprouting or deterioration during handling and storage. The studies are designed to provide information on composition (as determined by enzymatic assays) and on levels of enzymes in cereal grains; other units at the Center use this information for determination of soundness, characterization, and development of quality tests. Enzymes will be used to determine, selectively and specifically, trace amounts of nutrients or contaminants such as in mold, insect, or rodent infested grain. Examples of studies in this area include determination of sprout damage, differences in alpha-amylase in sprouted wheats and malts from various classes and locations, and development of a mobile unit for field determination of alpha-amylase.

Mycotoxins

Research is conducted to develop analytical procedures, preferably suitable for use in grain marketing channels, for detection of specific fungal components as measures of extent of invasion, mycotoxins, and other fungal metabolites; and to identify fungi-grain interrelations that may regulate invasion of particular grain types, varieties, or hybrids by specific genera or species of fungi. The approach used in those studies is to apply optimized extraction and chromatographic techniques and to simplify and make more effective initial extraction, cleanup, and final detection steps. Metabolites are evaluated as measures of fungal invasion on grains and are compared with mycological and such other tests as discoloration, germination, fat acidity, and odors. Differences in susceptibility to

invasion by fungi among grain types, varieties, or hybrids (especially sorghum) are investigated.

Corn and Sorghum Quality

The studies are conducted in a laboratory which assays the protein contents and chemical score (based on amino acid contents) of corn and sorghum. In addition, the laboratory compares various methods for routine determination of protein contents and quality in samples from plant breeders and from commercial channels.

BIOLOGICAL RESEARCH UNIT

Insects and microorganisms are the principal kinds of organisms that adversely affect the quality of grain. Insect and microbial activity in stored grains decrease germinability, discolor part or all of the seeds or kernel, cause weight loss, reduce the nutritional value, produce heating, and increase moisture; the latter two factors, in turn, bring about physical, chemical, and physiological changes in the grain. Some insects feed on whole grain, others on broken kernels thereby increasing the percentage of broken kernels and dockage; some microorganisms produce toxins that are injurious to man and to domestic animals. Grain and cereal products are subject to insect and microbial infestation, damage, and contamination while in the marketing channels. The Federal Government, the food storage, transportation, and processing industries, and the consumer suffer large monetary losses from grain insects causing damage and downgrading and making the products unfit for human consumption. The presence of insects and the damage done by them affects us adversely in the highly competitive foreign market. Another cause for concern in relation to foreign trade in grain is that pesticide and fumigant residues are receiving increasingly critical scrutiny in the European Common Market countries as well as in other parts of the world. Insects and pesticide and fumigant residues are of concern for the domestic market. There is urgent need for more acceptable and effective methods for preventing insect damage and contamination during storage, handling, processing, packaging, transportation, and retail distribution. The need is critical for effective pesticides and application methods that can be used in our domestic and foreign markets without leaving objectionable residues. Even more desirable is the development of effective preventive and control measures using biological, physical, mechanical, or other nonchemical means that would reduce or completely eliminate the application of pesticidal chemicals.

The Biological Research Unit is concerned with fundamental and applied biology of insects and microorganisms that infest stored grains and cereal products. Its primary mission is to gain adequate knowledge of such organisms and the storage environment to develop appropriate techniques and methods of pest management under experimental and practical conditions. Research is divided into the following areas:

Insect Biochemistry and Physiology

This area of research is studying the growth and development of stored grain insects to determine unique biochemical and physiological processes that are potential targets for new insect control agents. This approach to insect control uses a class of insecticides called biorational because of their specificity to insects and because they exhibit little or no adverse effects on man, wildlife, domestic animals, and the ecosystem. The program includes basic research in insect biochemistry, endocrinology, and morphology, and applied research in the development of biorational compounds that specifically inhibit particular aspects of an insect's physiological and behavioral processes. Compounds receiving special attention are insect growth regulators with hormonal activity (juvenile hormone, molting hormone, glucagon, and insulin) and those that interfere with exoskeleton production, energy metabolism, reproduction, and sensory perception. The susceptibility of strains of the confused flour beetle, red flour beetle, lesser grain borer, rice weevil, granary weevil, maize weevil, sawtoothed grain beetle, cigarette beetle, Indian meal moth, and navel orangeworm to these chemical agents is being investigated.

Pesticide Biochemistry

Studies are being conducted to develop new insecticidal formulations from chemicals that exhibit low mammalian toxicity as substitutes for approved chemicals currently in use. There are problems in retaining effective control of stored grain insects because some species are developing tolerance and resistance to present-day pesticides. Basic and ap-

plied research is directed toward establishing efficacy of new chemicals as grain protectants, residuals, and as vapor toxicants in addition to determining the concentration of residues remaining after application; measuring the response of insects to varying amounts of insecticidal materials applied to grain during an extended time; and elucidating the mode of action of certain organophosphorus compounds in insects. The effects of these compounds on *de novo* protein and nucleic acid synthesis and other cellular metabolic functions are being investigated using cultured embryonic cells of the Indian meal moth.

Insect Pathology

Investigations are being made to develop methods for using microbial insect pathogens to prevent and control insect infestations in stored grain and processed products. Basic and applied research entails studies of the structure, physiology, and mode of action of selected bacterial and viral insect pathogens; susceptibility of strains of the Indian meal moth and almond moth to *Bacillus thuringiensis* and granulosis virus, differential toxicity of *B. thuringiensis* isolates, and efficacy of commercial formulations of *B. thuringiensis;* structure, toxicity, and biosynthesis of the entomocidal protein of *B. thuringiensis;* and effects of commodity characteristics, storage environment, biology and behavior of the target insect species, development of resistance to pathogens, and interactions with unaffected insect species on the use of insect pathogens for stored grain insect control.

Pest Bionomics

Research in this area is being conducted to determine the influence of inert atmospheres—produced by exothermic inert atmosphere generators—on toxicity, fecundity, fertility, and development of the major stored grain insects. Other studies include examination of the influence of temperature and moisture on the response of insects to the atmospheres produced by an exothermic inert atmosphere generator; the effects of the application of modified atmospheres to bulk stored commodity ecosystems including insect populations, functional and biochemical properties of the treated commodity, and fungistatic activity; and the current costs of conventional chemical treatment of grain compared to the costs of installing and operating exothermic inert atmosphere generators for the control of insects in bulk stored grain, in cooperation with Economic Research Service.

This program also includes a study to identify biological problems (insect and microbial) associated with environments that occur in transported grain and that contribute to physical losses, reduction in quality, and increased transportation costs.

Genetic Resistance in Seeds

Basic and applied biology is being done with grains that exhibit preference, antibiosis, and tolerance to insects and microorganisms. Specific attention is being given to naked and hulled barleys and to several wheat varieties that exhibit differences in their response to certain insects and fungi. For those grains found to be resistant, efforts are being made to determine the site in the grain and the cause(s) of resistance. Planned work will involve genetics of resistance, hybridization techniques to combine resistant genes in seeds with desirable agronomic characters, resistance tests in advanced generation hybrids, and evaluation of resistant grains in laboratory and field trials. Specific lines of work will include isolation, purification, identification, and evaluation of chemical constituents of grains that repel or attract insects and microorganisms and determination of genetically controlled structural and morphological characteristics of resistant grain varieties.

ENGINEERING RESEARCH UNIT

The work of the Engineering Research Unit concerns the development and evaluation of techniques for handling, conditioning, and storage of grain that will enhance the maintenance of quality, order in marketing, and use of grains. Increased industrial and commercial demands for grains, plus expanding export markets, have created unprecedented problems in handling and conditioning large volumes of grains with increasingly stringent quality standards. The technological changes in grain production and harvesting, along with the current emphasis on environmental and fuel conservation considerations, have added to complex problems faced by the grain trade and by researchers working in this area. Specifically, researchers conduct work on (1) minimizing fuel energy required for grain drying, (2) measurement and control of dust from grain handling, and (3) reduc-

tion of damage to grain from handling. Recent progress in these areas of research is summarized as follows:

Minimizing Fuel Energy Required For Grain Drying

Three different solar collectors were used and two tests were conducted with solar systems that included thermal storage. Six tests were conducted on the 1976 corn crop. Three tests were conducted in 5.4-m-diameter bins with 2,500 bushels of wet corn. The other three tests conducted in 4.5-m-diameter bins filled with 750 bushels of wet corn included a comparison between an inflated tube-type solar collector with a projected area of 12.8m² and a combination collector-heat storage system with an area of 28.4m². A third bin was used as a control for corn dried with natural air without supplemental heat from solar collectors. The initial moisture content of the corn varied from 21.7 percent to 23.8 percent. The final moisture with the collector-heat storage system was 11.2 percent, that of the inflated solar collector was 12.3 percent, and that of the natural air drying was 12.5 percent. Because of favorable weather, the solar energy added little in drying effectiveness over that with natural air. Similar results were obtained for three large bin tests using a flat-plate solar collector with 14.4m² of collector area.

A second activity in this area of work is the use of desiccants and salt solutions as drying-heat storage media for grain drying by solar energy. Experimental studies and computer simulation of the regeneration of silica gel at temperatures obtainable from flat-plate solar collectors were conducted. Usually, silica gel is regenerated at 150° to 176°C. However, from laboratory tests it was found that silica gel could be regenerated successfully at a temperature of 55° to 82°, which can be achieved by a simple, flat-plate, solar collector. A mathematical model of the regeneration of silica gel at temperatures obtainable from flat-plate solar collectors was completed. Verification of the proposed model indicated that the experimental results were in agreement with the model. To estimate the parameters of the model, a numerical solution was compared with the experimental data. The necessary adjustments in the heat and mass transfer coefficients were then made to match the conditions of the model prediction and experimental results.

Preliminary design information is being obtained for a phase change material heat storage system. Several salt solutions are presently being evaluated according to their latent heats of fusion, melting points, corrosiveness, and availability.

Other work involves energy conservation in grain drying. A laboratory scale (5 bu of grain) heat recovery system was tested in which a heat pump and a heat-pipe heat exchanger were combined to recover and reuse heat from the exhaust air of a grain dryer. Compared to operating without heat recovery, net energy required to remove water from the grain was reduced 8 percent using the heat-pipe heat exchanger alone and 50 percent using the heat-pump and heat-pipe in combination.

Measurement and Control Of Dust From Grain Handling

Regulations that govern the permissible levels of particulate emissions are causing large grain elevators to increase their dust control measures. The additional dust that is separated from grain increases shrinkage and thereby becomes a factor in grain quality and creates additional dust handling and storage costs.

A method was developed for measuring the residual dustiness of grain samples. Dust was separated from grain by wet sieving in isopropyl alcohol while the fine particles were being dispersed by an ultrasonic cleaner. The dust particles were then separated from alcohol by filtering before being dried and weighed. The residual dustiness of grain samples was compared to the dustiness of grain that was handled in full scale facilities. The amount of residual dust separated from twenty to thirty 500-g grain samples was indicative of the total amount of dust collected by the dust control system during the handling of 33 to 56 metric ton lots of grain. Corn, grain sorghum, and wheat had average residual dustiness levels of .082, .070, and .025 percent, respectively, compared to fine dust levels of .080, .037, and .028 percent, that were collected during handling of large lots. Some portions of each grain lot were two to four times dustier than other portions of the same lot. Variations in residual dust levels were related to broken kernel and fine material formation and subsequent segregation that occurred during handling.

Grain dusts were characterized by measuring particle size distribution, density, heat of combustion, and ash, protein, fat, fiber, and moisture contents. There was much variation among different samples of dust. Data from dusts, obtained from different grains at commercial elevators, provided the basis

for investigating ways to handle, store, and use dusts separated from grain.

Reduction of Damage To Grain From Handling

The fragility of shelled corn continues to be a major source of marketing problems. Brittle corn breaks easily when handled, and often an excessive amount of broken corn must be removed to meet market standards. The market value of corn screenings is nearly always less than that of whole kernels. A few devices designed to reduce damage to grain flowing in spouts have been introduced in recent years. They are intended to reduce the velocity of grain almost to zero and then allow the grain to reaccelerate. Our two major efforts in this area are (1) to measure the effectiveness of commercial and experimental flow retarders in reducing handling damage to corn, and (2) to identify fundamental principles that may be used to reduce damage to corn in commercial handling.

Using flow-retarding devices to limit grain velocities reduced handling damage slightly. The correlation between velocity and reduction in breakage as more retarding devices were installed indicated that the impact forces resulting from high velocities contribute to grain breakage. The use of aerodynamic drag as a decelerating force shows potential usefulness as a flow retarder, although the particular design tested may not be optimum.

The difference in breakage between heat-dried and naturally dried corn was much greater than differences related to the flow retarders used. Reducing stresses produced in the drying process appears to be the most effective and practical method of preventing handling damage in corn.

GRAIN QUALITY AND END-USE PROPERTIES UNIT

Activities in the Grain Quality and End-Use Properties Unit are concerned with (1) identifying physical and structural characteristics and chemical components that govern or are associated with functional properties, (2) developing, improving, or evaluating (or all three) methods and instruments that can be used to objectively, rapidly, and accurately characterize and evaluate grain in domestic and export marketing channels, and (3) cooperating with plant breeders throughout the Great Plains and with agronomists, plant physiologists, entomologists, and biochemists at Kansas State University by providing milling, baking, and biochemical expertise and support for selective projects of mutual interest. Specifically, researchers:

(a) Determine and evaluate the functional (milling and breadmaking) properties of early generation and potentially new hard winter wheats bred for the Great Plains, and evaluate the earliest feasible generation of hard winter wheats bred for genetically high-protein content. Kjeldahl[1] (protein) analytical equipment and the 10-g mixograph, together with micro- and macro-milling and breadmaking equipment, are employed to determine functional properties of about 2,500 plant breeders' samples (10 g to 1,500 g).

(b) Develop new methods and techniques of determining chemical, milling, breadmaking, physical-chemical, and biochemical properties of hard wheats.

(c) Develop energy-conserving baking methods and high-protein nutritionally improved breads and evaluate nutritionally superior foreign proteins for bread production by applying the recently developed no-sugar formula and short-time (70-min) technique for breadmaking to high quantities of soy flour singly and in combination with other nutritious foreign proteins such as soy isolates, whey products, casein, nonfat milk solids, and gluten. Optimize baking techniques, oxidizers, and surfactants that may be a function of protein composition and interaction. Study the effect of above- and below-normal fermentation temperatures on malt requirement, fermentation time, proof height, proof time, and oxidation requirement in optimizing dough handling properties, loaf volume, and internal and external bread characteristics.

(d) Conduct studies that will reveal basic concepts of hardness in wheat.

(e) Develop biochemical fractionating and reconstituting techniques to relate functional (breadmaking) to biochemical properties of wheat-flour components and determine the chemical fractions and components of wheat responsible for quality differences. After literally taking the flours apart, corresponding gluten-protein, gliadin- and glutenin-protein (modified and unmodified), and other

[1] Trade names are used to provide specific information. Mention of a trade name does not constitute a warranty of the product by the U.S. Department of Agriculture nor an endorsement over other products not mentioned.

wheat-flour fractions of good- and poor-quality wheat-flours are interchanged, one at a time and in combinations, in the reconstituted flours. Fractions and reconstituted flours are characterized by physical, biochemical, and breadmaking techniques.

Research during the past year has been in the following areas:

Determination and Evaluation Of Functional Properties Of Potentially New Hard Winter Wheats

About 385 samples (1500 g) of agronomically promising new varieties and recent releases of hard winter wheat were characterized and evaluated in terms of their functional properties including wheat hardness; bolting properties and flour yield; flour ash; dough mixing, oxidation, and water requirements; bread crumb grain and color scores; and loaf-volume potentialities. About 26 percent of the samples had good milling, chemical, breadmaking, and physical-dough properties. Leading commercial wheat varieties of tomorrow are among them. A number of progenies, in addition, had genetically high-protein contents.

Evaluation of New High-Protein Hard Winter Wheats

For many years, wheat yields have gradually increased at the expense of protein content, which now is close to becoming a limiting factor, particularly when considering both home and export requirements. Now, plant breeders from commercial companies and from the Kansas, Nebraska, and South Dakota Agricultural Experiment Stations have developed genetically high-protein hard winter wheats that have other good milling and breadmaking properties. Even when breeding material does not involve known or deliberately introduced genes for high-protein content, we select for protein content, other factors being equal. Because of the wide diversity of present germ stock, selecting for protein content probably will increase significantly the average-protein content of future hard winter wheat crops. In addition, the new selections may have complementary genes for protein and be instrumental in stabilizing protein-content increases of wheats containing known genes for high-protein content. To emphasize the importance of increasing wheat protein, millions of human beings throughout the world need more protein in their diets. That fact, and that protein is a limiting factor in bakery products at home and abroad, and that the future supply of crop fertilizers may be deficient are three reasons for increasing protein content of hard winter wheats.

About 1,480 samples (8 g) of the earliest generation crosses, bred in Kansas for genetically higher protein contents than those of the present commercially grown varieties of wheat, were screened for protein content. About 285 progenies contained 1.5 to 4.4 percentage points and 35 contained 3.0 to 4.4 percentage points more protein than their controls.

About 1,240 small samples (40 to 100 g) of early generation progenies of hard winter wheats were micro-milled and evaluated for milling. Each sample of flour was subjected to certain analytical, water-absorption, and mixogram tests. About 240 (19 percent) had promising overall functional properties. Also, 92 of the 240 promising ones had 1.5 to 3.4 percentage points and 18 had 2.5 to 3.4 percentage points more flour protein than their controls.

Effects of Solvent Extraction On Lipid Composition, Mixing Time, And Bread Loaf Volume

Wheat-flour lipids were extracted with each of nine solvents: petroleum ether, n-hexane, n-heptane, benzene, chloroform, acetone, water-saturated 1-butanol, methanol, and 95 percent ethanol. Nonpolar solvents extracted substantially less lipids than the more polar solvents. Lipids extracted with nonpolar solvents contained less polar lipids than those extracted with polar solvents. Generally, as extracted bound or total lipids increased, mixing time increased and loaf volume decreased for reconstituted flours. Extracting lipids with each of the three alcohols reduced to zero or greatly impaired the gas-retaining capacity of gluten protein.

White Wheat Bran and Brewer's Spent Grains in High-Fiber Bread

Bran-enriched bread was superior in loaf volume, crumb grain, and crumb color to bread in which part of the flour was replaced with spent grains from brewing all-malt or malt-corn grits. The superiority of wheat bran in counteracting the adverse effects of fiber-poor diets on several diseases of Western civilization has been challenged by Eastwood and associates. Whatever the outcome of that controversy, bran from white wheats used in this study modified white bread characteristics less than fibers from other natural materials (that is, oat hulls used previously or brewer's spent grains

used in this study). The bran contains less cellulose than isolated and modified celluloses used in a previous study, but it contains a mixture of cellulose, hemicelluloses, pentosans, and related materials along with proteins of high biological value, B vitamins, and minerals.

About 7 percent white wheat bran can be added to flour without markedly modifying either its breadmaking parameters, that is absorption and mixing time, or the character of the bread. In terms of crude fiber content, such a bread could be equivalent to bread produced from a 90 percent extraction flour. Yet, it would have two advantages over the latter bread. It would contain substantial amounts of fibrous components present in the bran and at the same time, would retain the character of a white bread that is acceptable to consumers in the U.S.A.

The food additives status of two of the materials used in our studies, oat hulls and brewer's spent grains, is uncertain at present because they have not been used in significant amounts as food components. The use of oat hulls is objectionable because the sharp ridges on the hulls could be a serious irritant.

High-Yielding European Wheats: Determination of End-Use Properties

The baking method described to evaluate U.S. wheat varieties was equally effective for European wheats. European bread formulas, however, do not contain one or more of the ingredients (potassium bromate, non-fat milk solids, sugar, and shortening). Potassium bromate can be eliminated with no important effect on evaluation and differentiation, particularly when only undesirable, short-mixing varieties might be penalized. Also, milk can be eliminated without seriously affecting evaluation. Differentiation, however, would be decreased by about 25 to 65 cc volume responses that reflect the effect of milk on low and medium-high protein content flours (100 g), respectively. Eliminating milk would cut the oxidation requirement by about one-half and would essentially eliminate any need for potassium bromate. A formula containing no milk and no bromate would then require no more than 50 ppm ascorbic acid. If sugar is eliminated, each 100 g flour plus any added malt should contain a total of 30 to 50 α-amylase dextrinizing units (20° C) or 60 to 100 SKB α-amylase units (30°). Eliminating sugar is better than adding only 2 to 3 percent, as low levels of sugar depress loaf volume. The effect of shortening on loaf volume will vary from about 100 to 200 cc, depending primarily on flour protein content. Thus, shortening should not be eliminated unless the equally or more effective sucrose palmitate is added (0.30 to 0.50 percent, depending on source of yeast and other ingredients). Sucrose palmitate is approved for food use in England, France, Switzerland, and Japan.

Mixograph mixing time was highly effective in differentiating and evaluating breadmaking properties of flours milled from European wheats. The mixograph requires only 10 g flour; six to eight mixograms per hour can be run, depending on the time allotted each.

Breads made from 50:50 blends of a typical U.S. hard winter wheat flour and each of three European wheat flours were greatly improved compared to those from the European wheat flours alone. The U.S. wheat flour contained about 12 percent protein and the European wheat flours had one or more unsatisfactory breadmaking (functional) properties.

European wheats were categorized as follows: A, good loaf volume and medium to medium-long mixing time to point of minimum mobility; B, good loaf volume and short but satisfactory (fair) mixing requirement; C, satisfactory (fair) to good loaf volume and short (unsatisfactory) mixing time; and D, poor (unsatisfactory) loaf volume and short (unsatisfactory) mixing time.

Separation of Glutenin From Gliadin by Ultracentrifugation

The complete separation of glutenin from gliadin by ultracentrifugation at 435,000 × G and the entirely functional properties of the gliadin fraction are the ultimate conditions for studying the protein fractions of good- and poor-quality wheats.

Short-Time Baking Systems. A 70-Minute Sugar-Free Formula For Conventional and High-Protein Breads

Bread of high volume and lacy, well-structured crumb grain was made with a sugar-free formula (no added sugar), a 70-min fermentation time, and a straight-dough-batch procedure. With no sugar in the formula, a lag phase occurred in gas production. Lag time varied with source and potency (batch) of yeast. Lag-time differences within and between yeasts were equalized in terms of end-product by proofing to height. When fermentation time was decreased from 180 to 70 min, the re-

quirement for malt decreased 50 percent, and for potassium bromate ($KBrO_3$) it increased 200 percent. When nonfat dry milk was omitted from the formula, $KBrO_3$ requirement was reduced 50 percent. Adding 50 to 100 ppm ascorbic acid decreased $KBrO_3$ requirement by two-thirds. A low level of $KBrO_3$ in combination with a relatively high level (excess) of ascorbic acid effectively optimized loaf volume and crumb grain of bread. In the 70-min sugar-free formula, 84 g of wheat flour carried 16 g of high-protein supplements of high biological value and produced bread that had good volume and crumb grain and about 50 percent more protein than that made with wheat flour alone. Sucrose palmitate, shortening, sodium stearoyl-2-lactylate (SSL), and a combination of shortening and SSL were compared in the bread formula.

A Simple 100-Gram Dough Molder

The inexpensive, sled-like, hand-operated, laboratory molder that curls and compresses bread dough from 100-g. flour was evaluated against the Thompson laboratory machine molder by processing 29 flours of widely varying protein contents and other functional (breadmaking) properties. The correlation coefficient was $r = 0.99$ and the slope of the regression line was $b = 0.98$ for loaf volumes of doughs processed by the two molders. External and internal loaf characteristics were essentially the same for both molders. The standard error of estimate for loaf volume by the new hand-operated molder was 17.3 cc.

GRAIN QUALITY CHARACTERIZATION RESEARCH UNIT

The work of the newly established Grain Quality Characterization Research Unit concerns the development and evaluation of chemical, biochemical, physical and physicochemical methods, and instrumentation for characterizing and determining the quality of cereal grains. The information from those investigations is used to develop methods for evaluating cereal grains in marketing channels and developing, in cooperation with the AMS and the FGIS, proposals for modification and improvements in grain standards and grades. Specifically, researchers conduct basic and applied research on (1) the value and limits of objective tests in the present grain standards and development of methods to simplify, accelerate, and automate those objective tests; (2) methods to replace subjective evaluation in present grain standards by objective, simple, rapid, and automated assays; (3) methods that are not included in the present grain standards but which are needed to fully determine grain quality; (4) physical properties and composition of cereal grains; and (5) development and standardization procedures appropriate for evaluation of grain in laboratory and marketing channels. Recent progress in these areas of research is summarized as follows:

Determination of Moisture in Wet Grain

To store properly, sometimes grain must be harvested when it is too wet. Although instrumentation is available to measure the normal (approximately 14 percent) moisture content of grain, the results are not reliable if the moisture exceeds 29 percent. There is need to develop a fast, reliable method for measuring the moisture (up to 40 percent) in wet grain. Our approach has been to use pulsed nuclear magnetic resonance (PNMR) equipment. Weighing is not required and the results are obtained in approximately 1 minute. We are establishing the relationship between PNMR readings and percentage moisture (up to 40 percent) for several different grains—wheat, barley, sorghum, corn, and rice.

Degree of Milling of Rice

Studies are being conducted to develop an objective, reliable, and fast method that will measure how completely the outer layers are removed from rice by milling. Currently, a subjective method is generally used with variations in results because of different graders. Because more fat is in the outer layer of grain than in the endosperm, some laboratories relate the degree of milling to the amount of fat extracted. Other laboratories have attempted to relate the color of rice to the degree of milling. The International Association of Cereal Chemistry relies on a staining technique to make the fragments of the outer layers more visible on partly milled rice kernels. However, none of these methods are satisfactory. Our approach is to develop a physicochemical test that can be carried out in less than 10 minutes. The results must agree with the subjective evaluation of milled short, medium, and long grain rice samples that differ in the degree of milling.

Measurement of Protein In Hard Red Winter Wheat By Near Infrared Procedures

A simple, rapid, and reliable method is needed for measuring the protein in wheat. Results from such a method would permit binning wheat based on protein content at its first entry into marketing channels. Including the percentage of protein in the grain standards would be practical.

Two new near infrared (NIR) instruments for measuring the protein content of wheat easily and quickly are available commercially, and they are being used to aid in binning wheat according to protein content. We are studying the inter- and intra-laboratory reproducibility of the protein determination in Hard Red Winter wheat using 24 Kjeldahl laboratories and 30 laboratories using either Neotec 31EL or InfraAlyzer NIR instruments.

ECONOMIC RESEARCH SERVICE—COMMODITY ECONOMICS DIVISION

Grains and Feeds Program

The work of this unit encompasses the economic evaluation of a wide variety of subjects related to grain and grain products including the general areas of grain quality, of production costs, storage, marketing, and transportation analysis. Special areas of research include assessments of such current issues as grain standards, grain losses, dust emission, and the economic feasibility of solar grain drying.

Main objectives of these economic evaluations are (1) to provide economic assessments of new technologies and institutional approaches to grain production and marketing such as an evaluation of new criteria in grading and pricing, comparison of costs of solar drying with conventional systems, and an evaluation of proposed EPA dust emission standards; (2) to analyze the efficiency of assembly, processing and distribution of grains and grain products; (3) to conduct pricing and supply-demand analyses; and (4) to provide special analyses of current topics.

Basic to the research efforts is the interdisciplinary approach and environment afforded by the U.S. Grain Marketing Research Laboratory. This unit works in close cooperation with ARS personnel in providing economic evaluations related to insects, fungi, mycotoxins, handling equipment and methods, transportation systems, and storage methods.

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